2 The Ultimate Recyclable

All water on Earth, including the water that flows from our taps and the water we flush down the drain, is part of a natural cycle.

Estimated Time

Three 50-minute class sessions

Technology Tools/Skills Used in Chapter

Retrieving reliable information from the Internet and other media.

Safety Precautions/Concerns

None

Vocabulary

Acid rain
Aquifer
Atmosphere
Biosphere
Condense
Evaporation
Geosphere
Groundwater
Precipitation
Recharge
Runoff
Saturated
Surface water
Transpiration
Wetland

Chapter Objectives

Students will be able to:

1. Diagram and describe the path of water through the hydrosphere, geosphere and atmosphere (the water cycle).
2. Define and differentiate between weather and climate
3. Using a specific example, explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences to aquatic resources in Missouri.
4. Explain, using Missouri-specific examples, how the availability of fresh water for humans and other living organisms is dependent upon the water cycle.

Targeted Grade-Level Expectations

ES.2.E.7.a. Explain and trace the possible paths of water through the hydrosphere, geosphere, and atmosphere (i.e., the water cycle: evaporation, condensation, precipitation, surface run-off/ groundwater flow)
ES.1.D.7.a. Differentiate between weather and climate
ES.3.A.6.b.
ES.3.A.7.b. Provide examples of how the availability of fresh water for humans and other living organisms is dependent upon the water cycle
IS.1.C.6.a.
IN.1.A.6.a. Formulate testable questions and hypotheses
IN.1.B.6.a.
IN.1.B.6.b. Communicate the procedures and results of investigations and explanations through:

- **oral presentations**
- **drawings** and maps
- **data tables (allowing for the recording** and analysis **of data relevant to the experiment,** such as independent and dependent variables, multiple trials, beginning and ending times or **temperatures, derived quantities)**
- graphs (bar, single line, pictograph)
- **writings**

Reference Material for Teacher Background

- EPA Missouri Drinking Water page at *epa.gov/safewater/dwinfo/mo.htm*
- *en.wikipedia.org/wiki/Sewage_treatment*
- *howstuffworks.com/sewer2.htm*
- Impacts of Development of Waterways—Watershed Resources Fact Sheet #3 (FIS263)
- Missouri DNR Public Drinking Water page at *dnr.mo.gov/env/wpp/dw-index.htm*

- Nonpoint Source Water Pollution—Watershed Resources Fact Sheet #4 (FIS262)
- Strategies for Coping with Stormwater—Watershed Resources Fact Sheet #2 (FIS261)
- Stream Team Middle School Activity Guide by Mark Van Patten at *mostreamteam.org/activity_guide/contents.htm*
- Streets to Streams Guide (E00428)
- Streets to Streams Video (E00447)
- USGS Water Science for Schools wastewater treatment page at *ga.water.usgs.gov/edu/wuww.html*
- What Happened to the Stream in My Backyard? (STR238)
- Why Watershed Conservation—Watershed Resources Fact Sheet #1 (FIS260)

Safety Precautions/Concerns

None

Required Materials

- Large strip of butcher paper
- Crayons, markers, colored pencils or chalk
- 3 large foil roasting pans
- Squeeze bottle or pump sprayer containing water
- Food coloring
- Soil (use topsoil or freshly dug yard/garden soil—commercial potting soil is too light)
- 1-inch square of sod (grass with soil attached—available at lawn and garden supply store)
- Paper towels for spills
- Student Guide
- Notebook paper
- Pens or pencils

Activity 2.1: Exploration of Students' Current Understanding of the Water Cycle

This activity explores students' current understanding of the water cycle.

Estimated Time

25 minutes

Required Materials

- Large strip of butcher paper
- Crayons, markers, colored pencils or chalk

Procedure

1. Post a large strip of butcher paper on a classroom wall and provide crayons, markers, colored pencils, or chalk. Alternatively, a strip of sidewalk may be used or students may work individually using smaller sheets of paper.

2. Ask students to work together to create a mural to explore the following questions:
   - Where does water come from?
   - Where does water go when it rains?
   - Does polluted water stay polluted forever or can dirty water get clean again?
   - What does water have to do with weather?
   - Where does water go when we flush it down the drain?

3. Explain to the class that this chapter will help them understand the water cycle, how we get clean water to drink and why weather matters.

Activity 2.2: Teacher Demonstration of Water Runoff and Infiltration

This demonstration helps students understand runoff and the benefits of allowing precipitation to soak in to soil and vegetation.

Estimated Time

25 minutes

Required Materials

- 3 large foil roasting pans
- Squeeze bottle or pump sprayer containing water
- Food coloring
- Soil (use topsoil or freshly dug yard/garden soil—commercial potting soil is too light)
- 1-inch square of sod (grass with soil attached—available at lawn and garden supply store)
- Paper towels for spills

Procedure

1. Prepare in advance by filling one foil pan with soil so that it comes half way up the side on one end and gently slopes to the bottom of the pan, stopping about 2 inches from the opposite end of the pan. Gently pack the soil. Place the sod in another pan. Trim the sod to fit if necessary, leaving about 2 inches open at one end of the pan. Gently press the sod down. To simulate a hill, raise the sod end of the pan. Leave the third pan empty and raise one end of the pan.

2. Tell the class that the pans represent three different hills: one with plants growing on it, one with bare ground and one with pavement. The hills slope to streams, lakes or wetlands, which are represented by the clear spaces at the bottom of the hills. Ask students to watch carefully as you simulate rain on the three hills.

3. Use the squeeze bottle or pump sprayer to spray or trickle water onto the sod, the bare soil and the paved surface. Try to release the water at the same rate each time. (You may wish to ask student volunteers to do this under your direction.)

4. Ask students what happened in each case. (The water takes longer to run out of the sod-covered hill than the bare-soil hill and faster down the pavement than the soil. Also, more soil will flow into the water from the bare-soil hill than from the sod-covered hill.) Ask students to explain the differences.

5. Ask students to describe some situations in which soil might be washed into aquatic resources. (Possible answers include house or road construction work, farming row crops, dirt from roads and parking lots, poorly grassed lawns, etc.)

6. Tell the class to imagine that a man has spilled used motor oil on the ground while changing the oil in his car. Ask the class what will happen if oil were spilled on each of the three hills. Place a few drops of food coloring on each hill. (Food coloring runs quickly off the bare surface but is absorbed by the soil and the sod.)

7. Ask the class to predict what will happen when it rains. Use the squeeze bottle or pump sprayer to spray or trickle water onto the sod, the bare soil and the paved surface. (Colored water runs quickly off the bare surface, less quickly off the soil, and slowly from the sod.)

8. Use a cooperative learning activity to have students discuss the results observed and their implications for local aquatic resources.

Activity 2.3: Student Investigation of Weather and Climate

This activity helps students understand the water cycle and differentiate between weather and climate.

Estimated Time

35 minutes of in-class discussion over two consecutive days (25- and 10-minute discussions)

Required Materials

- 1 Weather Terms and Measurements Table for each student
- 1 Weather Observations and Measurements sheet for each student
- Pens or pencils

Procedure

Day one (25 minutes)

1. Review the water cycle with the class as needed based on the results of Activity 2.1.

2. Use a cooperative learning activity to have students generate ideas for ways to find reliable weather information. Be sure they include newspapers, internet weather sites and television or radio stations. Have students discuss how weather affects their daily lives.

3. Distribute a Weather Terms and Measurements Table to each student.

4. Lead class discussion of the weather terms and measurements described in the table. Ask students to describe some ways weather affects the availability of fresh water in their area.

5. Distribute a Weather Observations and Measurements sheet to each student.

6. Instruct students to use the sheet to record the day's weather data and bring the completed page to class the next day.

Day two (10 minutes)

1. Lead class discussion of weather data findings.

2. Have students add the Weather Observations and Measurements sheets to their science notebooks.

Weather Terms and Measurements Table

Term	Description or definition	Instrument of measurement	Units of measurement	Abbreviation
Air temperature (High = highest temperature of the day; Low = lowest temperature of the day	Hotness or coldness of surrounding atmosphere	Thermometer	Celsius or Fahrenheit degrees	°C or °F
Wind speed	Velocity of air movement	Anemometer	Miles or kilometers per hour	mph, mi/hr or km/hr, kph
Wind direction	Compass bearing from which wind is moving	Vane or windsock	None	N, S, E, W, NE, SE, NW, SW
Atmospheric or barometric pressure	Weight of the atmosphere over a unit area of Earth's surface	Barometer	Inches of mercury or millibars	inHg or mb
Relative humidity	Amount of moisture in the air as a percentage of the maximum possible	Hygrometer	Percentage	%
Precipitation	Amount of rain, snow, sleet or hail that reaches the ground	Rain gauge	Inches, feet or millimeters	in., ft. or mm
Cloud cover	Fraction of sky obscured by clouds	Direct observation	Description	Clear, scattered clouds, partly cloudy, mostly cloudy, overcast

WEATHER OBSERVATIONS AND MEASUREMENTS

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Objective

Obtain, record and present weather data.

Directions

1. Find a reliable source of daily information about the weather in your area.

2. Record today's weather data for your area. Be sure you report the source of each piece of data, the date and location for which it was reported.

Name: _____

Date: _____

Location: _____

Weather on _____ (date) for _____ (location)

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Activity 2.4: Student Reading and Research

This activity provides students with definitions and explanations about the path of water through the hydrosphere, geosphere and atmosphere (the water cycle) and helps students differentiate between weather and climate. It helps students understand where their tap water comes from and what happens to their wastewater.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 2: The Ultimate Recyclable. Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.
   1. What is the water cycle? Where does it start and where does it end? Where does water spend most of its time?
      The water cycle is the movement of water through the atmosphere, geosphere and biosphere. It starts anywhere water exists in any form; or, it has no beginning or end. Water spends most of its time in the oceans.
   2. What is weather? What is climate? How do they affect the quality and quantity of our water?
      Weather is the movement of water through the water cycle, or the observed atmospheric conditions in a given time and place. Climate is the average atmospheric conditions in an area over many years. Weather and climate affect the quality and quantity of our water in many ways, including:
      - **The water cycle is the natural process that purifies Earth's water.**
      - **How much water there will be in a certain region in a given part of the water cycle depends on the amount of rainfall, the effect of temperature on evaporation and the uptake of water by plants during the growing season.**
      - **Even small changes in the global cycle can cause droughts or floods at the local level.**

3. What kind of climate does Missouri have?
   Answers may include: Missouri tends to have hot, humid summers and cold, damp winters. Some parts of Missouri receive abundant rain in late spring and may experience flooding. Other places may receive sparse rain in mid-summer and experience drought. Throughout Missouri, plants have plenty of time to grow each year. But every part of Missouri can expect to experience below-freezing temperatures each winter.

4. What is surface water? What is groundwater?
   Surface water is water that flows over the land. Groundwater is water that soaks into the ground.

5. Where does water go when it runs off a street?
   Stormwater runoff goes through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed.

6. Where does our water come from? How does it get to our faucets?
   Assess locally. Answers should include identifying the water source as either surface water or groundwater and whether or not the water is treated.

7. What happens to water after we've used it? Where does it go when it goes down the drain?
   Assess locally. Answers should include the treatment method used.

Activity 2.5: Student Investigation of Tap Water and Wastewater

This activity helps students understand where their tap water comes from and what happens to their wastewater.

Estimated Time

Varies—class time may be provided or research may be assigned as homework. Allow at least 25 minutes for in-class questions and discussion.

Required Materials

- Notebook paper
- Pens or pencils

Prepare in advance

Conduct your own investigation to determine where the school's tap water comes from, how the school's tap water is treated, where the school's wastewater goes and how the school's wastewater is treated.

Procedure

1. Use a cooperative learning activity to have students generate ideas about where they think their school and home tap water come from. Lead class discussion of various possibilities, including untreated groundwater (many individual domestic-use wells in rural areas), treated groundwater (many municipal wells) and treated surface water (many municipal water supplies). Have students work in groups to talk through the steps water must take to get from a source to the tap. Have students generate ideas about how they would go about finding out where their water comes from, both at school and at home. (Ask parents, look at water bill, call local water utility, etc.)

2. Have students generate ideas about where they think their school and home wastewater goes. Lead class discussion of various possibilities, including septic systems and sewage lagoons (many individual domestic systems in suburban and rural areas), small-scale "package" treatment systems (many domestic systems in suburbs) and large-scale treatment plants and wastewater wetlands (many municipal systems). Have students work in groups to talk through the steps wastewater must go through to get from toilets back into the environment. Have students generate ideas about how they would go about finding out where their wastewater goes, both at school and at home. (Ask parents, look at water bill, call local water utility, etc.)

3. Assign investigation of tap water source and wastewater treatment as homework or in-class research. Have students write science notebook entries describing the process and outcome of their research. When completed, lead class discussion of findings.

Activity 2.6: Student Investigation of Weather

Students apply what they have learned in the preceding activities to create science notebook pages to record weather conditions and observations in preparation for their field study day.

Estimated Time

25 minutes

Required Materials

- Notebook paper
- Pens or pencils

Procedure

1. Instruct students to work in groups to decide the best way to record weather conditions and observations as part of their field study day.

2. Have each group create a data table and have each student make a copy for his/her science notebook.

Chapter 2 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. How does the water cycle purify water?
   a. Water flows through underground aquifers
   b. Every time water evaporates it becomes pure again
   c. Water vapor condenses to form raindrops
   d. All of the above

2. Where does the water cycle start?
   a. Anywhere water exists in any form
   b. Water vapor condenses in clouds
   c. When precipitation falls to the ground
   d. In the oceans

3. What is weather?
   a. Hot, damp summers and cold, dry winters
   b. The movement of water from soil through plant roots and stems, and out the leaves into the atmosphere
   c. Average atmospheric conditions in an area over many years
   d. The movement of water through the water cycle

4. What is climate?
   a. Hot, damp summers and cold, dry winters
   b. The movement of water from soil through plant roots and stems, and out the leaves into the atmosphere
   c. Average atmospheric conditions in an area over many years
   d. All of the above

5. What is surface water?
   a. Water absorbed by plants and released slowly into waterways
   b. Water that soaks into the ground
   c. Water that flows over the land
   d. Water frozen in glaciers, snowpacks and polar ice caps

6. What is groundwater?
   a. Water absorbed by plants and released slowly into waterways
   b. Water that soaks into the ground
   c. Water that flows over the land
   d. Water frozen in glaciers, snowpacks and polar ice caps

7. Where does water go when it runs off a street?
   a. To wastewater treatment plants for processing before being returned to the environment
   b. To drinking water treatment plants, then through pipes to our taps
   c. To pick up air pollution, forming acid rain
   d. Through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed

8. Where does water go when it goes down the drain?
   a. To a wastewater treatment plant, septic system or lagoon for processing before being returned to the environment
   b. To drinking water treatment plants, then through pipes to our taps
   c. To pick up air pollution, forming acid rain
   d. Through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed

Chapter 2 Assessment

Directions

Write your own answer for each of the following questions.

1. Define weather and climate and differentiate between them. How are they related? Describe Missouri's climate.

2. Justify the following statement: The availability of fresh water for humans and other living organisms is dependent upon the water cycle.

3. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as groundwater wells, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Missouri.

4. Diagram and describe the path of water through the biosphere, geosphere and atmosphere (the water cycle). Show at least five processes that are part of the cycle. Be sure to label the parts of your diagram correctly. Use the back of this page.

Chapter 2 Assessment Answer Key

Multiple-choice questions

1. How does the water cycle purify water?
   b. Every time water evaporates it becomes pure again.

2. Where does the water cycle start?
   a. Anywhere water exists in any form

3. What is weather?
   d. The movement of water through the water cycle

4. What is climate?
   c. Average atmospheric conditions in an area over many years

5. What is surface water?
   c. Water that flows over the land

6. What is groundwater?
   b. Water that soaks into the ground

7. Where does water go when it runs off a street?
   d. Through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed

8. Where does water go when it goes down the drain?
   a. To a wastewater treatment plant, septic system or lagoon for processing before being returned to the environment

Write-in questions

1. Define weather and climate and differentiate between them. How are they related? Describe Missouri's climate.
   Definitions:
   - **Weather is the movement of water through the water cycle, or the observed atmospheric conditions in a given time and place.**
   - **Climate is the average weather conditions over longer times.**

   Difference:
   - **Weather is the actual observed atmospheric condition at a given time and place.**
   - **Climate is the atmospheric conditions one would tend or expect to observe at a given time and place.**

   Relationship:
   - **Climate is determined and understood by observing and recording weather over many years. It includes seasonal variations in weather.**

   Missouri's climate: Answers may include:
   - **Missouri tends to have hot, humid summers and cold, damp winters.**
   - **Some parts of Missouri receive abundant rain in late spring and may experience flooding. Other places may receive sparse rain in mid-summer and experience drought.**
   - **Throughout Missouri plants have plenty of time to grow each year, but every part of Missouri can expect to experience below-freezing temperatures each winter.**

2. Justify the following statement: The availability of fresh water for humans and other living organisms is dependent upon the water cycle.
   Answers may include:
   How much water there will be in a certain region in a given part of the water cycle depends on the amount of rainfall, the effect of temperature on evaporation and the uptake of water by plants during the growing season. Even small changes in the global cycle can cause droughts or floods at the local level.

3. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as groundwater wells, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Missouri.
   Answers may include:

Activity/technological solution	Potential benefit	Potential drawback
groundwater wells	provide water for various uses: drinking, cleaning, irrigation, etc.	can take thousands of years to recharge, pumping out water may cause ground subsidence (sinking or caving in)
paved roads/parking lots	improve surface transportation	water running off surface carries heat and pollutants
sewer systems	carry away waste	contaminate water bodies
use of fertilizers	increases plant growth	results in overgrowth of algae
use of herbicides	kills weeds	toxic to other plants and animals

4. Diagram and describe the path of water through the biosphere, geosphere and atmosphere (the water cycle). Show at least five processes that are part of the cycle. Be sure to label the parts of your diagram correctly. Use the back of this page.
   Refer to FIG. 2.1. Answers should include at least five of the following:
   - **evaporation**
   - **condensation**
   - **precipitation**
   - **interception (plants catch and slow precipitation)**
   - **infiltration or recharge (water soaking into the ground)**
   - **transpiration (plants releasing water through photosynthesis)**
   - **surface runoff or stream flow**
   - **groundwater flow or discharge**
   - **water storage in ocean, atmosphere, icepack, ground or fresh surface waters**

Enrichments

Project WET:

- Dust Bowls and Failed Levees
- Get the Ground Water Picture
- Incredible Journey
- Piece It Together
- Poetic Precipitation
- Poisoned Pump
- Sparkling Water
- Thirsty Plants
- Water Models
- Wet Vacation
- Where Are the Frogs?

Project WILD Aquatic:

- Alice in Waterland
- Water Wings
- What's in the Air?
- Where Does Water Run?

Video clips:

- Mississippi River Maintenance Man
- Missouri River Relief

Guest speakers:

- Local drinking water treatment plant worker. If invited for Activity 2.5, the speaker may take the place of the research assignment.
- Local wastewater treatment plant worker. If invited for Activity 2.5, the speaker may take the place of the research assignment.
- Local weather reporter. If invited for Activity 2.3 or 2.6, the speaker may be able to assist with instruction.

Demonstrations:

- Enviroscape model
- Stream Table

Service learning:

- Storm drain stenciling
- Litter pickup

Additional enrichments:

- School weather station
- Field trip: Wastewater treatment plant tour (drinking water treatment plants have been off limits to the public since the terrorist attacks of 9/11)